TSS – A VIABLE MEASURE OF STORM WATER POLLUTANTS?

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ABSTRACT

Storm water best management practices (BMPs) have been historically evaluated for effectiveness and selected based on their ability to remove total suspended solids (TSS). EPA and a number of states and local agencies have adopted a criterion of 80% removal of TSS for BMPs and for determining acceptance of manufactured structural BMPs. Many agencies use TSS as a surrogate for trace-element pollutants found in storm water runoff.

The USGS found that the TSS method of analysis results in unacceptable large errors when determining concentrations of suspended material found in open-channel flow and provides data that can result in erroneous pollutant load computations of several orders of magnitude. The National Highway Runoff Data and Methodology Synthesis raises questions about the utility of TSS and trace-element data collected by storm water programs and the use of TSS data in the assessment, design and maintenance of BMPs.

The ASCE/EPA National Stormwater Database and the Center for Watershed Protection's 1997 storm water database report that most of the public domain BMPs do not achieve the 80% TSS removal criterion. EPA's consultants have found that TSS may be a poor indicator for other pollutants in storm water runoff and that current sampling and analytical methods understate solids actually found in runoff.

EPA's November 2002 guidance on the development and implementation of TMDLs will likely require municipalities to propose and justify BMPs that will achieve compliance with TMDLs - water quality standards - as part of the NPDES permit process. Methods of sample collection, management and analysis contribute to the erroneous TSS results. New methods for characterization of pollutants of concern are needed if better data is to be obtained and used in decisions on compliance with TMDLs and NPDES permits and selection of BMPs that will result in actual reduction in loads of storm water pollutants. The historic use of TSS will no longer suffice and a new approach is needed.

Studies by Dr. John Sansalone of Louisiana State University and the USGS have found that the size and characteristics of particles in storm water runoff and associated pollutants are a better measure of storm water pollution and provide a better method for assessment of BMP performance. The characteristics of particles and associated pollutants throughout a range of particle size distributions (PSDs) offers a new approach for the characterization of storm water pollutants, the design and selection of BMPs and provides data essential to the implementation of many TMDLs.

KEYWORDS

suspended sediments, suspended sediment concentrations, total suspended solids, total dissolved solids, particle size distribution

INTRODUCTION

Storm water managers need to think beyond the traditional characteristics or properties of storm water runoff in the development and implementation of storm water management programs. The concept that material suspended in storm water runoff travels as individual discrete spherical particles, is of inorganic origin and has a specific gravity of 2.65 is not supported by today's research and a change will be difficult for many storm water professionals to accept and embrace. Many storm water monitoring and BMP evaluation studies have been designed using methods that were developed to sample and analyze wastewater using these concepts. These studies primarily use influent/effluent TSS removal as a measure of efficiency.

Today's research is finding that particles in storm water runoff have different properties than those in wastewater in terms of particle gradation and shape, pollutant mass and loading relationships to particles, specific gravity and distribution of trace elements across particle gradations. The collection, management and analysis of samples representing the wide range of particle sizes of suspended sediments, gross pollutants and even oil and grease in storm water runoff will require the application of techniques that have yet to be standardized or commonly accepted.

The continued use of total suspended solids (TSS) data as a measure of pollutants suspended in storm water, to express BMP performance, to design and select BMPs and as a surrogate for pollutants of concern is being questioned. New and improved techniques for the collection, management and analysis of storm water samples are needed to better characterize storm water pollutants and determine pollutant loadings to achieve successful implementation of TMDLs. These techniques and new approaches are also needed to evaluate the pollutant removal effectiveness of storm water BMPs.

BACKGROUND

Total Suspended Solids as a Measure of Suspended Sediments in Storm Water

Sediment has been identified as the most widely occurring pollutant in the Nation's waters. The terms suspended sediment, total suspended solids, total solids, suspended solids, suspended material and nonsettleable solids have been used interchangeably to describe the suspended solid-phase material in storm water runoff. Sediment is comprised of particles derived from rocks, biological materials or chemical precipitates and can include pavement dust and particles, atmospheric dust, natural soils, traction sand and cinders, vehicle rust particles, brake pad and tire dust and particles, trash and plant and leaf material. Many heavy metals and other trace elements are associated with sediments (Bent et al. 2001).

Total Suspended Solids was initially used as regulatory criteria (40CFR Part 133) to define secondary treatment for Public Owned Treatment Works (POTWs) under the federal Clean Water Act (CWA). The Total Suspended "Matter" Method was originally intended for use with wastewaters, effluents and polluted waters (Gray 2000) and allowed the removal of non-homogenous material such as leaves, sticks, fish and lumps of fecal material prior to analysis (FWPCA Methods – 1969).

More recently TSS has been used to characterize pollutants in storm water runoff and in the Coastal Zone Act Reauthorization Act (CZARA) 1993 guidance specifying management measures for sources of nonpoint pollution to define the performance of BMPs. The 80% criterion evolved from the 1993 guidance issued to implement the 1990 CZARA and was based on performance data for public domain systems like dry and wet ponds, wetlands, filters, infiltration and marshes. Removal of TSS is currently used by many agencies to specify acceptable performance of structural manufactured BMPs.

The 80% TSS removal CZARA guideline (EPA 1993) was based on the removal efficiencies for storm water control practices such as constructed wetlands, wet ponds and infiltration basins reported by Schueler (1992). Lloyd (1997) and Schueler (1997) subsequently found that these systems do not achieve the 80% TSS removal guideline and EPA (August 1999) reported that these systems achieve only 50-80% removal of TSS.

Why TSS Is An Inappropriate Measure of Storm Water Pollutants

The USGS and the Federal Highway Administration in 1996 initiated the National Highway Runoff Data and Methodology Synthesis. The program undertook an extensive study on the use of the TSS method of analysis to characterize suspended sediment in storm water runoff. The USGS in November 2000 issued a Policy and memorandum on the collection and use of TSS data that:

- Stated that the use of TSS data of water samples collected from open channels is not appropriate and the TSS analytical method can result in unacceptably large errors and is fundamentally unreliable.
- Established the Suspended Sediment Concentration (SSC) method of analysis (ASTM D 3977-97) as the USGS standard for determining suspended sediment concentrations in surface water samples.
- Reported that the TSS method of analysis produces data that are negatively biased by 25 to 34% with respect to the SSC method and that the biased TSS data can result in errors in load computations of several orders of magnitude.
- Determined that there is no reliable way to adjust TSS data to estimate suspended sediment without corresponding SSC data.

Discrepancies between the TSS and SSC methods were primarily attributed to the procedures used in the TSS method to obtain aliquots or sub samples by pouring or pipetting, particularly when very fine sand size (62 μm) and larger particles are present (Gray 2000). Standard Methods indicates that sampling, subsampling and pipetting two-phase and three-phase samples may introduce serious errors in solids analysis (Standard Methods 1995).

URS Greiner/Woodward Clyde (1999) in a study for EPA on the measurement of TSS in runoff found that:

- Although many pollutants are highly associated with particulates, the correlation between TSS and specific pollutants varies.
- Studies indicate that different metals are present in particulate form in different amounts and the particulate fraction of copper and zinc varies significantly.
- Generally TSS may be a poor indicator of the concentration of other pollutants.
- Current sampling and analysis methods understate large solids and street surface data indicates that many pollutants are present in these solids (medium sand and larger).
- The CZARA 80% TSS removal standard is not supported by the National Pollutant Data Base (Schueler 1997) or the EPA/ASCE BMP database.
- Available BMP design information does not explain the difference in BMP performance.
- Proposes a different approach for specifying national guidance for BMP requirements and goals.

The USGS (Breault 2000) notes from an analysis of the NURP data that the coefficients of variation for TSS and metals data range from 0.8 to 1.0 indicating that measured concentrations in urban runoff may vary by more than plus or minus two orders of magnitude. This wide range in NURP data supports the conclusion in the above referenced issue paper of the poor correlation between TSS and pollutants.

Equally important is the misconception among many storm water practioners that there is a meaningful distinction between TSS and Total Dissolved Solids (TDS) and there are significantly different environmental effects when the pollutants are "dissolved". Timperley (1999) notes that the poor relationship between aquatic toxicity and total dissolved chemical concentrations stems from the arbitrary definition of dissolved particles - less than 0.45 µm. Substances below 20 nm (0.02 µm) are truly dissolved and more closely related to bioavailable concentrations. The utility of substantial amounts of historic dissolved trace-element data has been questioned (Breault 2000) because of sample methods and sample management techniques that allow dissolved-solids matrix partioning.

Particle Size Distribution of Storm Water Sediments

The highly quoted Sartor and Boyd (1972) studies have provided the earliest information on PSD and associated pollutants. They defined street surface contaminants as being those materials found on street surfaces which are capable of being washed off during common rain storms. Approximately 85% of the total solids, 75% of the heavy metals and 72% of the phosphates were associated with particles >104µm (fine sand).

Table 1

STREET SURFACE CONTAMINANTS

FRACTION OF POLLUTANTS ASSOCIATED WITH EACH PARTICLE SIZE RANGE

(% by Weight)

	Particle Size, Micron (µm)				
	< 104	104 – 246	246-840	840-2000	> 2000
Total Solids	15%	28%	25%	8%	24%
Heavy Metals (a)	25%	20%	16%	20%	19%
Phosphates	28%	24%	7%	1%	0%
Nitrogen (b)	38%	20%	20%	12%	10%

(a) Chromium, Copper, Zinc, Nickel & Mercury
(b) Kjeldahl Nitrogen

Ref. Sartor and Boyd (1972)

Shaheen (1975) found 90% of the street dirt solids, 83% of the heavy metals and 70% of the total phosphorous to be associated with particles > 75µm (fine sand).

Table 2

STREET SUFACE CONTAMINANTS, I-495

FRACTION OF TOTAL ASSOCIATED WITH EACH PARTICLE SIZE RANGE

(% by Weight)

	Particle Size, Micron (µm)				
	< 75	75 – 250	250 - 420	420 - 850	850 - 3350
Heavy Metals (a)	17%	41%	20%	13%	6%
Total PO_4	31%	44%	16%	12%	6%
Nitrogen (b)	19%	36%	14%	14%	17%

(a) Chromium, Copper, Zinc, Nickel & Mercury
(b) Kjeldahl Nitrogen

Ref Shaheen (1975)

A study of phosphorous sources in storm water runoff in Madison, WI found that approximately 75% of the sediment mass in street-dirt resides in the >250 µm particle-size fraction and less than 5% of the mass was found in the particle sizes <63 µm (Waschbush et al. 1999). The difference in PSD found in *runoff* from previous studies at the site and in the street-dirt was attributed to loss of the material between the street and outfall from street sweeping and settling in catch basins and bedload not sampled by the automatic samplers. This study also found that the >250 μm particle-size fraction contributed nearly 50% of the total phosphorous mass and the leaf fraction contributed an additional 30%.

Sansalone (1997, 1999, 2001b and 2002) has performed the most extensive recent research on the characteristics of particles and the pollutants associated with those particles in the wide range of PSDs found in storm water and snow melt *runoff* and reports that:

- The predominance of total surface area and mass of heavy metals is associated with the coarser fraction of particles (200-850 μm).
- PSD monitored in street *runoff* found over 90% of the material >117 μm and 50% >555 μm.
- The 425-850 μm range has the highest total surface area and below 100 μm the total surface area is small.
- Snow melt *runoff* studies indicate that there is a wide gradation of particulate material deposited from highway snowbanks; the very coarse fraction (>1,000 μm) dominates the total dry mass; the surface area is predominantly associated with fractions >500 μm; and, the predominance of heavy metals is associated with the coarse fraction and the surface area.

Wide ranges in the PSD measured from similar land uses has been reported (Bent et al. 2001). It is of interest that the PSD data reported by Sartor and Boyd (1972) and Shaheen (1975) for street surface material is comparable to that reported by Sansalone (1997 and 2001b) for highway *runoff*, but this data is significantly greater than the PSD reported for *runoff* by other studies (Burton and Pitt 2002). A possible explanation of this difference is that Sansalone's studies are based on samples taken of the entire highway *runoff* and would be representative of material on the highway surface while many other studies have relied on automatic samplers for collection of *runoff* samples.

Several agencies (Portland 2001 and Washington DOE 2002) have developed protocols for evaluation of emerging storm water treatment technologies that provide for laboratory studies using material with PSDs and TSS concentrations considered "typical" of runoff. The Washington protocol material has PSDs with 99.9% less than 150 μm, 93% less than 75 μm, 80% less than 50 μm 30% less than 10μm with a mean PSD of 19 μm and specific gravity of 2.65. This material is significantly smaller than has been found from other areas cited above and not typical of specific gravity of smaller particles.

Studies of highway runoff have found that many of the sub-40 μm particles are organic with specific gravities less than 1.5 (Sansalone 1997), and can range from 1.1 to 3.5 ((Bent et al. 2001). Sansalone (personal communication) also reports that suspended sediments in the PSD ranges of 250-9500 μm can have specific gravities as low as 1.4.

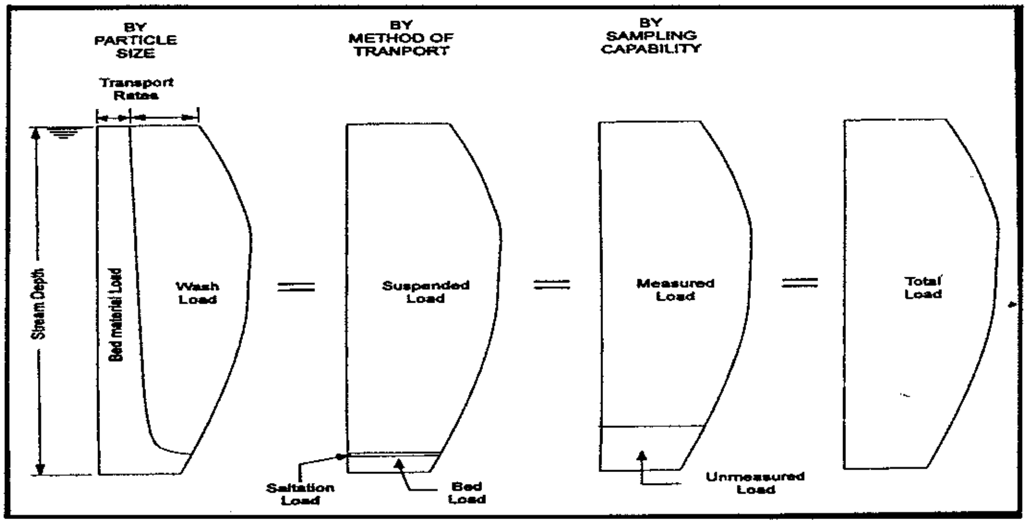
Investigation of the PSD data developed under the National Urban Runoff Program (NURP) (Driscoll, et al. 1986) found that samples were primarily collected using automatic samplers and PSDs were determined using results of settling columns tests. This test method has been found to be extremely difficult because many particles (fine sand sized and larger) settle before the test actually begins (Pisano 1996). The intent of this portion of the NURP was to determine the fine particles in *runoff* and not that component that would easily settle Driscoll (personal communication 2002). The NURP results cited in a number of publications are probably not representative of the PSD in storm water *runoff*.

The differences between street dirt and *runoff* samples may be attributed to a number of factors including: particles may be reduced in size due to vehicular traffic; heavier material may be trapped in inlet sumps or storm drains and not reach the *runoff*; different site conditions with some sites having unfettered runoff; previously deposited material in the storm drains acting as a filter for subsequent flows; use of automatic samplers that cannot collect larger particles; sample management that excluded larger particles; different analytical techniques some of which only report "true" PSD, etc.

A growing interest in the use of PSD to aid in the characterization of storm water pollutants is evidenced by the recent Ninth International Conference on Urban Drainage held in Portland, Oregon where over 15 papers were presented that addressed PSD and pollutant relationships.

Sampling of Suspended Sediments in Storm Water Runoff

The methods for sampling storm water runoff are perhaps the fundamental reason for the significant difference in the TSS and PSD data reported by various studies. Suspended sediments travel as bed-material load and wash load (Figure 1) with particles <40 μm well mixed within the water column as wash load; however, as the particle size increases above 62 μm a gradient is formed with larger particles at the bottom (Bent 2001). The size of particles in bedload will be a function of channel slope, specific gravity of the solids, particle shape and flow energy generated by individual storm events. These characteristics present challenges in the selection of sampling methods and equipment and defining the sampling period.



Ref. EPA 1997

Figure 1

Edwards (1999) describes methods and equipment used in collection of the bedload, and discusses the importance of isokinnetic sampling, orientation of the sample tube and presents "17 Optimum Criteria" when using automatic samplers to sample the wash load. Samples collected non-isokinetically by automatic samplers may not provide data representative of cross section concentrations and PSDs when sand-sized material is present (Bent et al. 2001). The importance of isokinnetic sampling and orientation of the sampling tube are described by Winterstein (1983).

An evaluation of the effectiveness of an urban storm water treatment unit found the removal efficiency comparing influent and effluent loads at 25%, but was 33% when the unsampled bedload material was accounted for (Waschbusch 1999). The difference was attributed to the bedload that the automatic sampler could not effectively collect and the use of a Coulter counter to determine PSD. The results indicated that almost no sand (>63 μm) was in the runoff and no particles were >250 μm, yet 78% of the mass collected in the sump was >250 μm. A similar study by Kinnetic Laboratories (1996) of runoff from a parking lot found the PSD in all runoff samples <62 μm yet greater than 80% of the sediment captured in the BMP was >62-125 μm particle-size range.

Much of the data collected under the NURP program and during the Phase I storm water program relied on automatic samplers for sample collection. The frequently quoted "National Pollutant Removal Performance Database for Stormwater Best Management Practices" (Schueler 1997) only included studies that used automatic samplers.

The USGS indicates that automatic samplers are not designed for collection of bedload and research is needed to develop and test samplers to collect representative samples of bedload (Bent 2001). Bedload samplers should be used to supplement automatic samplers in order to obtain more accurate particle size and distributions in storm water runoff (Pitt 2002). Obtaining representative samples of the wide range of pollutants with vastly different properties is "An aged old problem that the profession has yet to wrap its arms around" (Pisano, personal communications 2002).

IMPLICATION FOR STORM WATER PROGRAMS

The USGS assessment of the TSS method of analysis and the above assessments of PSD data has important implications for storm water management programs. EPA TMDL Guidance (EPA 1999) indicates that WLAs should be expressed as (1) numeric maximum allowable loads, (2) required numeric reductions in pollutant loads and/or (3) narrative effluent requirements. The guidance recognizes that it will be difficult in the first round of TMDLs to develop WLAs for episodic sources including storm water runoff; however, a WLA may be developed as additional information is gathered and water quality models and TMDLs are refined. The guidance anticipates that these sources may be initially controlled through BMPs and narrative effluent requirements.

Although EPA's guidance suggests that control of storm water discharges would be through narrative requirements and BMPs, there are a number of TMDLs where numeric WLAs based on TSS data are being established for storm water discharges and BMPs are being required that will implement specific waste load reductions.

Perhaps of equal importance to storm water dischargers is the recent EPA Environmental Appeals Board Decision (2002) that rejected the requirement that storm water NPDES permits must include numeric effluent numeric limits to ensure compliance with water quality standards. The Appeals Board remanded the permit to EPA to develop support that the NPDES permit BMPs will ensure compliance with water quality standards.

The EPA Office of Water November 22, 2002 guidance to its regions clarifies the EPA regulatory requirements for establishing WLAs for storm water discharges and establishment of water quality based limits in NPDES permits to implement the TMDLs and implements the Appeals Board decision. The guidance requires the NPDES process document that selected BMPs will achieve implementation of the TMDL - achieve water quality standards. The guidance anticipates that NPDES permit writers would require municipalities provide that documentation.

The USGS (Bent 2000) states that "perhaps the broadest implication of this systematic problem in the TSS analysis method is for the interpretation of the performance of sediment-removal BMPs." They further state that: "When the TSS analysis method is used, these artifacts will have several important consequences for the assessment, design, and maintenance of BMPs, including:

- the variability in grain-size distributions for different periods of storm runoff and site to site may confound meaningful analysis of BMP effectiveness;
- the necessary volume of sediment-retention structures may be under designed; and

- maintenance schedules for sediment removal from these structures may not be adequate because sedimentation rates may be greater than expected."

Since the effectiveness of almost all storm water BMPs is tied to the removal of suspended sediments it is critical that the measurement sediments in storm water runoff not be biased by use of the TSS method of analysis.

USE OF EXISTING TSS DATA

Regulatory Purposes

Major public expenditures dating back to the NURP and the November 1990 Phase I monitoring requirements have occurred to characterize pollutants in storm water runoff Data generated by these programs related to suspended sediments is now questioned because of the USGS and various researchers findings regarding the procedures used in the collection, management and analysis of samples.

A careful and critical review of existing TSS data and the method of sample collection, sample management and analytical procedures are needed before existing data is used for regulatory compliance decisions, in the development of TMDLs and in the design and selection of BMPs. This review should determine whether:

- The "17 Optimum Criteria" (Edwards 1999) were met when automatic samplers were used to collect runoff samples.
- Comparable sampling was conducted when samples are collected with automatic samplers.
- The entire sample was processed if runoff sediment PSD was >63 µm or sample splitters were used or homogenization procedures documented and resulted in representative sub samples.

Dissolved trace-element data should also be questioned if samples were not immediately filtered upon collection or collected using automatic samplers.

A "No" answer to any one of these factors should result in the data not being used in the development of TMDL WLAs, determination of regulatory compliance or enforcement actions and to determine efficiency of BMPs or in the design and selection of BMPs unless correction factors are applied.

Guidance for BMP Evaluations

A number of protocols have recently been developed for the evaluation, verification or to determine acceptance of manufactured BMPs. A comparative analysis of the requirements of these various protocols reveals conflicting procedures, analytical methods, evaluation criteria and standards of performance that create a gauntlet for manufacturers of storm water treatment systems to gain acceptance. Many of the requirements were not addressed during evaluations of public domain systems. Several of the protocols as previously discussed place specific limits on TSS concentrations and PSDs that are considered in determining removal efficiencies. There is a need to provide uniform procedures for evaluating BMPs pollutant removal efficiency and perhaps most important to develop a protocol on tests that must be undertaken to demonstrate the capability of both public domain and manufactured BMPs to reduce pollutant loads under a wide range of flow conditions.

BMP Acceptance Criteria

State and local agencies have adopted the 80% TSS removal guidance to implement the CZARA program, to define the acceptance of manufactured BMPs and have presumed that public domain BMPs (ponds, swales, etc) can meet the guideline.

The USGS has questioned the use of TSS data in the design, maintenance, interpretation of the performance of sediment-removal BMPs (Bent 2001). This raises significant questions about the appropriateness of studies done to date and use of 80% TSS removal as a guideline in BMP selection. Effluent quality has been suggested as a more robust measure of BMP efficiency (Strecker, et al. 2001).

TRANSITION FROM TSS TO PSD - ISSUES THAT NEED TO BE ADDRESSED

The transition from TSS to PSD as a tool to characterize storm water pollutants must overcome some of the limitations that have been used in the collection, management and analysis of TSS samples. It will also require that uniform procedures be adopted for determining PSD and more consistent reporting of these procedures.

Sample Collection

The ability of automatic samplers to sample the wide range of particles in storm water runoff is questioned and Pitt (2002) states "it is well known that automatic samplers do not sample the largest particles that are found in the bedload portion of the flows." Burton and Pitt (2002) further recommend that bedload samplers be used to supplement automatic samplers in order to obtain more accurate PSDs in storm water runoff.

The use of automatic samplers has been found to narrowly define the TSS and PSD of material that is sampled. In spite of the growing recognition of the automatic sampler limitations the ETV (NSF International 2002) and State of Washington (WASDOE 2002) protocols require that data be collected using automatic samplers and several other program protocols state that studies should use automatic samplers.

The traditional equipment and techniques used to collect fluvial sediment data appear to be ill-suited for the needs of the 21st century and a vision for production of sediment –data at the national level involving the development and acceptance of sediment surrogate technologies was discussed at the April-May 2002 Subcommittee on Sedimentation (Gray 2002). The Subcommittee's efforts and the above studies bear close watching to determine if there are better techniques available to obtain representative samples of storm water runoff for BMP evaluation studies.

Ideally samples should be collected at various points on the hydrograph in order to construct a "true' pollutograph to allow full characterization of pollutants throughout storm events and development of BMPs that will address not only the mass of pollutants, but also those having the greatest environmental impacts.

Sample Management

Gray (2000) identified sample management as the fundamental difference between the SSC and TSS methods of determining suspended sediment. The USGS overcomes this by using cone or churn splitters to obtain representative sub samples (Capel 1996) and the SSC method measures all sediments and the mass of the entire water-sediment mixture.

It is important that samples be obtained and processed to ensure that they are representative of the physical, chemical and biological properties of the pollutants that is actually discharged or that a BMP "actually sees". Wet sieving of samples will produce samples that are the most representative.

Partitioning between the dissolved and suspended-solids phases are of concern when sampling the dissolved matrix affecting suspended and dissolved pollutant concentrations by several orders of magnitude (Breault 2000). Special consideration must be given to sample handling times when collecting samples for trace-element analysis.

Measurement of Suspended Sediment

The TSS method of analysis of suspended sediment should not be completely abandoned at this time. Suspended sediment concentrations should be determined using both the SSC ***AND*** TSS methods using split samples until correlation data is developed that may permit use of historic TSS data. The SSC method of analysis (ASTM D 3977-97 Method C) provides useful information on the size distribution of particles. The cost of each of these tests has been found to be nominal in terms of the overall cost of an evaluation study.

Methods for Determining PSD

The Methods for determining PSD of fluvial sediments rely on predrying samples, processing the sample through a nest of sieves with the PSD of particles smaller than 62 μm determined by pipet analysis, hydrometers or use of newer surrogate techniques. The drying process and physical shaking may significantly alter the size of the particles from that in the original sample. The pipet and settling methods to determine the particle sizes rely of Stokes Law that assumes that particles are of spherical shape and have uniform fall velocities based on specific gravities of 2.65 (Guy 1969). Studies previously cited have found that particles are not spherical and have specific gravities that range from 1.1 to 3.5.

Several methods call for removal of organic material prior to the PSD analysis. The PSD should be determined for both the "true" or inorganic portion and the "apparent" or organic and inorganic components and include specific gravity of each. BMP evaluation projects may also want to incorporate settling velocity and more advanced studies on characterization of pollutants in runoff should include mass and surface loadings, trace element distributions across the gradations, particle shape and specific surface area.

During the past 5 to 7 years the storm water profession has begun to use surrogate technology to automatically monitor and record suspended sediment concentration and/or PSD. While some of these technologies have shown promise and have been specified in monitoring protocols (WASDOE 2002) they are not universally accepted (Gray 2002). Field determination of the PSD with these new technologies must be compared to samples that are sonified in the laboratory. Results from the use of these new techniques should be compared with data collected by current methods to avoid creating a bias.

Analysis for trace-elements should be performed across the various particle gradations (PSD) to allow selection of BMPs that are best capable of addressing these pollutants of concern.

Standardize and Reporting of Methods and Protocols

The failure to report on sampling, sample management and analytical procedures and equipment have severely limited the utility of data collected by storm water monitoring programs and BMP evaluations. The transition to use of PSD to characterize storm water pollutants will present even greater challenges if data is to be compared because of the various methods for determining PSD.

CONCLUSIONS

A review of current methods of storm water runoff sample collection, management and analysis found that new and improved techniques are needed to characterize storm water pollutants and determine the effectiveness of BMPs. This review found:

- Many of the current methods and techniques used by storm water programs for sample collection, management and analysis have significantly underestimated the concentration (TSS) and loadings of suspended sediments, the PSD of those sediments and overestimated the pollutants associated with the sediments.
- Existing data obtained from the TSS method of analysis used to estimate suspended sediment in storm water runoff should be critically reviewed before using in development of TMDLs, for regulatory purposes or selection of BMPs.
- New and improved techniques or methods for sample collection, management and analysis are needed to characterize all pollutants in storm water runoff. These methods must be standardized to ensure that study results can be compared
- Improved characterization of storm water pollutants will require determination of PSD (particle gradation), pollutant mass and loading relationships to particles, specific gravity and distribution of trace elements across particle gradations.
- New approaches are needed for determining the effectiveness of sediment-capture BMPs to demonstrate pollutant removal efficiencies and loading reductions
- The previously determined efficiencies of public domain system can no longer be presumed.
- The new techniques, methods and approaches may be adapted from other programs that have been developed to assess sediments and pollutants in natural waters, the coastal zone and oceanographic waters as well as advanced storm water programs.
- During transition from use of TSS to PSD to characterize storm water pollutants it is essential that standard procedures be adopted for sample collection, management and analysis and all reports and studies fully document procedures and methods used.

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